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# Risk-Taking in High-Stakes Competition: Evidence from Olympic Indoor Volleyball

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**Abstract**

How do elite athletes adjust risk-taking across score contexts and tournament stages, and how do these patterns differ between men's and women's tournaments? We address these questions using a novel, manually coded rally-level dataset from the 2024 Olympic volleyball tournaments, covering 8,670 rallies from 52 men's and women's matches. We operationalize risk through observable tactical choices — serve type and attack placement — and estimate how these choices respond to score context, set progression, and playoff stakes. We find that risk-taking is systematically gendered and context-dependent: men attempt riskier serves as sets near their end, while women grow more conservative when protecting a set lead. In attacking, both genders turn more cautious late in sets. This asymmetry aligns with prospect theory since serving is a loss-domain decision that invites risk-seeking, while attacking is a gain-domain decision that invites risk aversion. Contrary to expectations of caution under elimination pressure, both genders take more risks in the knockout stage. These findings extend behavioral models of risk to a high-stakes team sport setting, with implications for coaching and performance analysis.

**Keywords**: risk-taking, prospect theory, gender differences, high-stakes games, sports economics, Olympic volleyball

**JEL classification**: D81, Z20, J16

# 1 Introduction

In the final moments of a tight Olympic volleyball match, a server faces a pivotal choice: unleash a high-powered jump serve that could score a winning ace at the risk of missing, or opt for a safer float serve to ensure the ball stays in play. Such split-second decisions encapsulate a fundamental question in competitive sports: when do athletes take risks, and how do pressure and context shape those choices? These decisions are far from trivial – at the elite level, a single risky play can swing the momentum of a game or even decide a championship. Understanding the determinants of risk-taking in high-stakes professional sport is therefore crucial for both theory (to refine models of decision-making under pressure) and practice (to inform coaching and performance strategies). Volleyball is an ideal setting for such inquiry. The sport is organized around discrete rallies that function as repeated, observable decision points. Context changes rapidly (score margin, phase of set, rotation, opponent adjustments), while institutional rules are transparent and stable. Unlike many contact team sports, volleyball allows researchers to classify risk at the action level (serve type, attack zone and direction, quick combinations) and to observe how those choices evolve within and across sets. This microstructure enables a behavioral analysis that links tactical moves to real-time shifts in pressure and incentives.

The primary goal of our study is to capture systematic asymmetries in choice under uncertainty: to trace how changes in stakes affect these asymmetries, and to understand how contextual factors shape within-game and within-tournament variation in risk-taking.

One of the key dimensions of this variation is gender. Decades of work in behavioral economics and psychology document consistent gender differences in risk preferences, with men typically more willing to accept variance and women more attentive to potential losses. In elite sport, these differences are often patterned. In volleyball specifically, our focus is on how men and women adjust risk in response to context rather than on absolute levels alone. Building on gendered patterns reported in related literature, we expect and test for asymmetries such as: (i) men escalating risk in moments that many athletes treat as "loss-domain" situations (e.g., late-set serving), and (ii) women expressing greater caution when a lead must be protected or when the score is finely balanced (e.g., deuce). These expectations recognize that gendered responses can reflect potentially distinct affective dynamics under stress.

The Olympic Games provide a uniquely clean empirical environment to study these mechanisms. Men and women compete under identical rules and tournament design, minimizing insti-

tutional confounds. The structure of the Olympic volleyball tournament – group phase followed by knock-out rounds – creates variation in competitive stakes: group matches allow recovery from mistakes; playoffs impose elimination. By coding every rally from all completed men's and women's matches (more than 8,000 rallies across 52 matches), we observe risk choices as they unfold under maximum-pressure conditions.

We use this evidence to test specific hypotheses drawn from behavioral theories: broadly, we ask (1) whether male players exhibit a higher propensity for risky plays than female players; (2) whether athletes become more conservative as the pressure of a set's endgame manifests; (3) how having a lead (or facing a tied score) influences risk-taking, potentially differently for each gender; and (4) whether the shift from round-robin play at the group stage to knockout matches changes teams' risk profiles. By addressing these questions, our study contributes to the understanding of decision-making under pressure in high-stakes games. Our goal is to provide a clearer picture of how context and gender intersect to shape strategic choices in one of the most demanding team sports, offering insights that could benefit both theorists interested in the principles of risky decision-making and practitioners seeking to optimize performance on the court.

Our results indicate that risk attitudes in volleyball differ systematically between men and women, and shift dynamically with score context, set progression, and tournament stage. Men are consistently more risk-taking in serving, while women show stronger risk aversion in late rallies. When competitive stakes are highest in playoff matches, both genders converge toward more aggressive strategies, despite the higher potential cost of errors.

The remainder of the paper is organized as follows. Section 2 provides literature overview on risk-taking decisions and the corresponding gender differences. Section 3 formalizes the framework: we explain main volleyball rules, discuss the notion of risk in volleyball, and formulate our main hypotheses. Section 4 introduces the dataset of volleyball rallies played at the 2024 Olympic volleyball tournament. The methodology of our research is described in Section 5, while the empirical results are presented in Section 6. Section 7 discusses the results and links them to the main theoretical concepts related to risk. Section 8 concludes.

## 2 Literature Review

The study of risk propensity under uncertainty originated in behavioral economics and cognitive psychology. A pivotal contribution was made by Kahneman and Tversky (1979), who proposed the prospect theory. According to this model, behavior under risk is determined not by absolute gains but by changes relative to a subjective reference point. The model explains asymmetry in decision-making: individuals tend to act more cautiously in the domain of gains and more riskily in the domain of losses. Over the past decades, prospect theory has been widely applied to understand decision-making in various environments including asset pricing (Barberis, Huang and Santos, 2001), migration decisions (Clark and Lisowski, 2017), political behavior (McDermott, 2004), and TV shows (Hersch and McDougall, 1997, Säve-Söderbergh and Sjögren Lindquist, 2017).

Prospect theory has proven particularly useful in explaining behavior in sports contexts, where decision-making often takes place under pressure and uncertainty, which makes this industry especially interesting for behavioral researchers. The theory helps explain shifts in behavior depending on whether the team or individual athlete perceives itself to be in a domain of gains or losses. An important test of prospect theory in professional sports is provided by Mochon (2024), who examines reference-point-dependent risk-taking in the NBA. The author shows that teams are more likely to attempt the riskier three-point shot, rather than the less risky two-point shot, when they are in the loss domain relative to their reference point, which is fully consistent with the predictions of prospect theory. Importantly, the reference point is neither singular nor fixed: teams' choices depend on the current score difference, the number of points scored by the opponent in the previous possession, and pre-game expectations (win probability and opponent strength). Moreover, the influence of the reference point strengthens toward the end of a quarter (mental accounting effect) and toward the end of the game, as well as when a three-point shot could tie the score (break-even effect). These findings demonstrate that even professional athletes in high-stakes environments exhibit systematic behavioral shifts rather than strictly rational optimization. Similar patterns are observed across other sports: Bartling, Brandes, and Schunk (2015) demonstrate that soccer players exhibit reference-dependent behavior and receive more cards from the referee when they are behind the expected result, whereas their coaches make excessively offensive substitutions in the same situation. However, not all suboptimalities are related to loss aversion. Romer (2006) showed that American football teams systematically avoided optimal fourth down plays, but loss aversion cannot solely explain this behavior.

Risk-taking can also be analyzed through the prism of the tournament theory. Rank-order tournaments considered in Lazear and Rosen (1981) can be beneficial to risk-averse or risk-loving agents depending on the prize scheme. Further theoretical modifications of the rank-order tournament model include adding new dimensions of risky decision-making (Hvide, 2002). Laboratory experiments show that risk-taking crucially depends on correlation between the outcomes of the risky strategies for contestants (Nieken and Sliwka, 2010). Note that in the sports context the game is usually antagonistic. The model in Gürtler, Struth, and Thon (2023) demonstrates that athletes, in general, may react to the increasing number of competitors by increasing the level of risk-taking. In particular, biathletes choose higher skiing intensity before the shooting exercise when there are more close competitors.

Loewenstein et al. (2001) proposed the alternative "risk-as-feelings" model. This framework emphasizes that emotional responses, such as anxiety, excitement, and confidence, can dominate over rational probability and outcome evaluations. In sports contexts, this implies that observed risk-taking or risk-avoidance may reflect affective reactions to competitive pressure rather than stable risk preferences.

The issue of gender differences in risk-taking behavior has received extensive empirical support. A meta-analysis by Byrnes, Miller and Schafer (1999) found consistent differences, showing that men are generally more risk-prone than women. Charness and Gneezy (2012), based on a series of economic experiments, demonstrated that men engage in more aggressive investment behavior, even when given the same information. Croson and Gneezy (2009) emphasize that women tend to perceive risk as a threat, while men interpret it as an opportunity. Säve-Söderbergh and Sjögren Lindquist (2017) provide an argument that gender differences may develop in adults while boys and girls, in contrast, do not make statistically different decisions in a TV show game "Junior Jeopardy!". Evidence from the same game "Jeopardy!" shows that the opponent's identity can be important: women take more risk when paired against men (Jetter and Walker, 2018). In chess, male chess players adopt more aggressive strategies when facing female opponents, even at a cost to their winning probability (Gerdes and Gränsmark, 2010).

Physiological distinctions are presented in the work of Lighthall et al. (2012), which used functional magnetic resonance imaging (fMRI), a neuroimaging method that measures brain activity by detecting changes in blood flow associated with neural activation. The study found that under conditions of acute stress, men exhibited increased activation in the striatum, a region involved

in reward processing and decision-making, whereas women showed reduced activation in the same area. This neurological divergence suggests that men may have a higher readiness to take risks under pressure, possibly due to heightened sensitivity to potential rewards. Meanwhile, Eagly and Wood (1991) emphasize the social and cultural foundations of such gender differences, arguing that risk behavior is shaped not only by biology but also by gender norms developed during socialization. According to this perspective, masculinity is socially associated with agency, assertiveness, and dominance, while femininity is linked to caution, emotional sensitivity, and a preference for interpersonal harmony.

Empirical studies in extreme and Olympic sports contexts further expand on these gender-based behavioral patterns. Frick (2021) observed that women remain underrepresented in extreme sports such as cliff diving, which limits their exposure to high-risk, sensation-seeking environments. However, among women who reach the elite level, their degree of risk propensity is comparable to that of men. Böheim and Lackner (2015), in a study of jumping disciplines, found that women made fewer risky decisions than men and could improve their performance by adopting riskier strategies. These findings support the existence of behavioral asymmetry in strategic contexts where risk is associated with a high cost of error.

Apart from gender, other individual personality traits may also play a crucial role in explaining differences in risk-taking. Dohmen et al. (2011) reported that age, height, and parental background have an economically significant impact on willingness to take risks. A significant contribution to understanding individual differences in risk propensity was made by Zuckerman (2006), who proposed the sensation seeking model. Sensation seeking is defined as a biologically rooted trait characterized by the pursuit of novel, intense, and potentially dangerous experiences. Another approach was proposed by Raab and Johnson (2007), who showed that expert athletes often rely on the "take-the-first" heuristic: they generate decisions quickly and frequently act on the first option that comes to mind, which often proves to be optimal. This not only reduces decision time under pressure but also minimizes perceived risk. In volleyball, where decisions must be made within seconds, this heuristic plays a crucial role guiding players toward rapid, intuitive choices in serving, setting, and attacking under pressure.

A growing body of empirical studies has examined how cognitive and tactical decisions translate into actual match outcomes. To keep the focus of this paper, we will mention just volleyball-related papers. The study by Silva et al. (2014), based on volleyball world championship matches, found

that successful serves (aces), attack efficiency, and reception quality had the greatest influence on team success. Reception errors were associated with a defeat. Surprisingly, blocking errors were more common among winning teams, possibly indicating a more aggressive playing style. Asčić et al. (2024) compared jump serves and float serves in the Croatian Men's Volleyball Super League. Jump serves were more effective, resulting in more aces and forced opponents' errors, but also had a higher error rate. This is a classic example of a high-risk, high-reward strategy. Fatahi et al. (2022) reported strong associations between set zone and attack quality; patterns highlight the importance of coordination for fast and precise attacks. Monteiro, Mesquita and Marcelino (2009) confirmed that attack efficacy and defensive play (digs) are directly associated with set outcomes.

Thus, risk in volleyball is expressed through specific tactical choices: type of serve (jump vs. float), direction of attack (line vs. diagonal), set distribution, and block density. These behavioral patterns are shaped by both individual traits and game context. Building on this literature, the present study classifies the following actions as high-risk tactical choices: the power (jump) serve, which maximizes pressure on reception at the cost of a higher error rate; the float serve, interpreted as a conservative, low-risk alternative; the down-the-line attack, which demands precision and is vulnerable to blocking despite its potential to surprise defenders; and the middle attack from zone 3, which relies on fast coordination between setter and hitter, thereby increasing the probability of error if execution is not optimal. These categorizations are consistent with prior analyses of serve and attack risk-reward trade-offs in elite volleyball (Asčić et al., 2024, Marcelino, Mesquita and Sampaio, 2011, Palao, Santos and Ureña, 2004, Silva et al., 2014), and they form the operational definition of risk-taking adopted in this study. However, most prior studies in volleyball have focused primarily on the effectiveness of specific game actions such as serve success, attack efficiency, or reception quality, as key predictors of team performance. While these works provide valuable insights into tactical patterns associated with winning outcomes, they do not address the underlying decision-making process or the strategic trade-offs athletes face when selecting between safer and riskier options during play. In response to this gap, the present study shifts the focus from outcome-based analysis to a behavioral perspective examining how risk-taking decisions are shaped by game context. Drawing on prospect theory, we explore how factors like score dynamics, set progression, tournament stage, and gender composition influence players' choices under uncertainty.

# 3 Theoretical framework

Volleyball is a sport that offers clearly segmented decision points (rallies), with observable trade-offs between conservative and aggressive actions, such as float versus jump serve, or cross-court versus line attack. Unlike in many other team sports, volleyball allows for systematic tracking of risk choices on a rally-by-rally basis, making it an ideal setting to observe how athletes modulate risk in real time, depending on score dynamics, match phase, and team role. Thus, the application of prospect theory to volleyball provides both conceptual and methodological value, bridging the models of decision-making and empirical sport performance.

## 3.1 Volleyball rules

Prior to the main analysis, it is useful to outline some key volleyball rules. In volleyball, there are 6 players on the court during a rally. The playing area of a standard volleyball court is conventionally divided into six zones forming two lines — the front row (zones 4, 3, 2) and the back row (zones 5, 6, 1). The outermost zones in the front row are 2 and 4 (Figure 1).

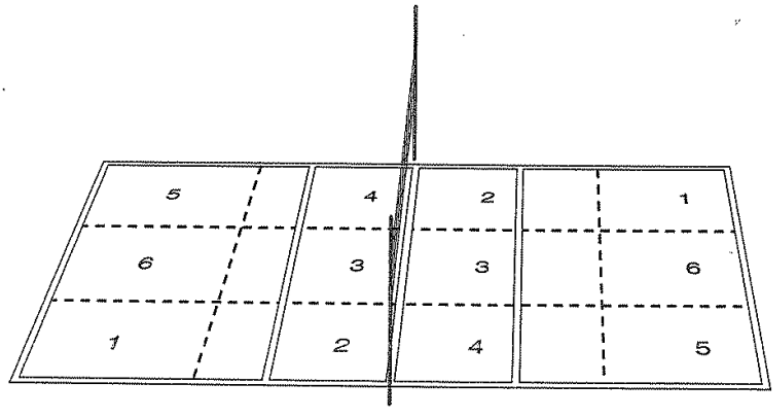


Figure 1: Court zones in a volleyball game. The attacking positions include zones 2, 3, and 4. Source: Dearing (2018)

The two lines on the sides perpendicular to the net are called the sidelines. The far lines parallel to the net are called the end lines. The near lines parallel to the net are called the attack lines (Figure 2).

According to the rules of volleyball, after a team wins the serve back from their opponents, the players must rotate one position clockwise. This means a player moves from zone 1 to zone 6, from zone 6 to zone 5, from zone 5 to zone 4, and so forth. However, this rule only applies at the

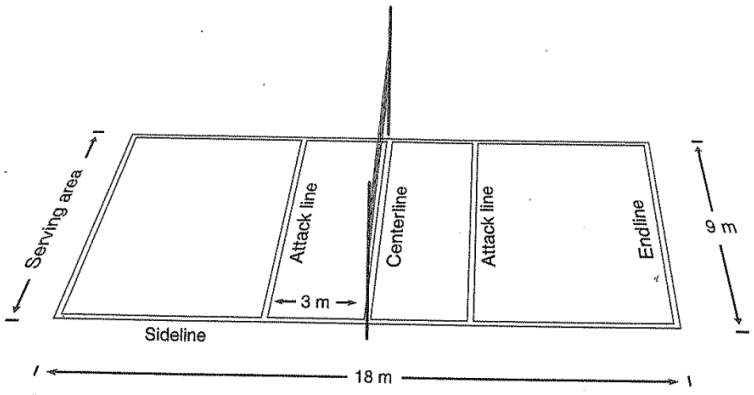


Figure 2: Court lines in a volleyball game. Source: Dearing (2018)

moment of the serve. Once the serve is made, players are free to move and switch positions during the rally as they see fit. To take full advantage of this flexibility, the vast majority of professional teams use a special tactical system which is designed to maximize the players' specialization. The core idea is that each player has a specific position and role on the court.

**Attackers:**

Middle Blocker: Their main task is to set up blocks, moving to the needed zone along the net, and attack quick sets. They mainly play in the front row and are substituted in the back row after serving.

Outside Hitter: They specialize in reception in the back row and attacking in the front row. Sets up blocks in the front row only in their zone.

Opposite Hitter: They specialize in attacking from both the front and back rows.

**Setter**: They make the second contact, setting passes to attackers for offense.

**Libero**: They play only in the back row, usually substituting for the middle blocker. Specializes in reception.

In this system, there is always exactly one setter and five attackers on the court, so it is called the "5-1" system. This system is based on a clear distribution of playing functions among team members according to their positional placement on the court. In the 5-1 system, the setter plays a key coordinating role, sequentially moving between the zones according to the established clockwise rotation rules. A distinctive feature of this system is that regardless of the setter's position on the court, the setter maintains his or her primary function of organizing attacks. However, the setter's participation in other game elements varies depending on his or her current position. For example, when in the back row, the setter cannot perform jump tips near the net.

There are always two outside hitters on the court. In the initial rotation, they stand opposite each other so that exactly one is always in the back row and one is in the front row. In the back row, the outside hitter moves to zone 6 and is responsible for receiving balls that land near the end line. In the front row, the outside hitter moves to zone 4, where they attack high outside sets. Most often, all sets from poor receptions go to them. Similarly, two middle blockers stand opposite each other. In the front row, they move to zone 3, responsible for organizing blocks and attacking. Since the attack comes from the center, three opposing blockers can defend against it if the set is high. Therefore, middle blockers attack with faster sets compared to outside hitters. In the back row after serving, they are usually substituted by the libero. During the rally, the libero moves to zone 5.

There is always one setter. In the front row, the setter moves to zone 2, from where he or she makes all sets. In the back row, the setter moves to zone 1 and after his or her team's reception, setter runs to the area between zones 2 and 3 to set for an attacker and then returns to zone 1. Opposite the setter stands the opposite hitter. He or she also moves to zone 2 in the front row and zone 1 in the back row. Opposite hitter's main task is attacking from both the back and front rows. Often the opposite hitter is excluded from serve reception.

The functioning of the 5-1 system provides several significant tactical advantages. The constant presence of three attacking players at the net creates wide opportunities for diverse attacking combinations and complicates the opponents' blocking actions. At the same time, maintaining one setter allows for a unified style of attack organization and ensures predictable sets for attackers.

## 3.2 Risk criteria

Risk is operationalized as tactical choices with high potential rewards but also higher probabilities of error. Since tactical schemes in professional volleyball are fairly standardized and most teams use similar game models, we can identify universal criteria for assessing risk levels (Table 1).

The first criterion is the distribution of attacking actions between zones 2, 3, and 4. In the 5-1 rotation system, attacks can come from three different directions (zones 2, 3, and 4). Attacks from the central zone (zone 3) are typically considered the most risky. This is explained by blocking organization specifics – in the central zone, the defending team can deploy three blockers, which requires the attacking team to increase their attack speed. In contrast, attacks from the outside

Table 1: Ranking of volleyball actions by risk level.

| **Action type** | **Lower-risk options** | **Higher-risk options** | **Rationale** |
|---|---|---|---|
| Direction of attack | Cross-court | Down-the-line | Narrower angles and higher block exposure increase risk |
| Attack zones | Zone 2 (diagonal), Zone 4 (outside) | Zone 3 (middle quick) | Middle attacks require precision and often face triple blocks |
| Serve | Standing / jump float | Short serve / jump power (cross-court / down-the-line) | Aggressive serves disrupt opponents but raise error probability |

*Notes: Ranking reflects tactical trade-offs between efficiency and error probability. Used to validate operationalization of risk.*

zones 2 and 4, where blocks are typically formed by two players, present lower risk.

The second criterion is the ratio of down-the-line to cross-court attacks from the outside zones. When attacking from zones 2 and 4, players can choose between hitting down-the-line or hitting cross-court. Line attacks are characterized by higher risk due to the shorter distance to the sideline and end line, along with limited options to avoid the block. Cross-court hits, offering a wider attack angle and larger target area, are less risky.

The third criterion is the distribution of serve types, ranked by increasing risk level: standing serve, float serve cross-court, float serve down-the-line, short serve, jump serve cross-court, and jump serve down-the-line. The more complex and aggressive the serve (such as a jump serve down-the-line), the higher the precision requirements, increasing the error probability. Conversely, simpler serves (like standing serves or float serves) are less risky but also less effective, as they are easier for opponents to receive.

Note that we cannot formally distinguish between individual risk-taking and team tactics. However, since the final decision in the episode is always taken by a single player without consulting with teammates or coaches, we tend to interpret this context as an individual decision (perhaps, with some prematch inputs from the coach that can be taken into account before the player's decision is made).

### 3.3 Hypotheses

The goal of this study is to identify the factors that influence the degree of risk in decision-making during volleyball matches. Our research is grounded in the evolutionary principle that risk aversion is a fundamental behavioral trait emerging from natural selection in environments with systematic risk (Zhang et al., 2014). Since a volleyball match represents a context of systematic, correlated risk for a team, we proceed from the assumption that players are predominantly risk-averse. Based on this premise, we formulate the following hypotheses:

**H1** (Gender). Male players are more risk-prone than female players (partly due to biological and psychological factors).

**H2** (Set dynamics). Toward the end of sets, players reduce their level of risk and adopt more conservative decisions, since each rally carries greater value.

**H3** (Set leadership). Teams leading in sets are more likely to take risky game decisions, as the score advantage provides "safety cushion" against mistakes.

**H4** (Tournament stage). In playoffs, players take fewer risks than in group-stage games, because the higher cost of errors in elimination contexts encourages more cautious behavior.

Our study contributes to the literature by testing these propositions in a team discipline with individual decision-making. Behavioral economists and psychologists, coaches and performance analysts can all benefit from understanding how gender and context interact to shape the timing and intensity of risky decisions on the volleyball court.

## 4 Data

The 2024 Olympic Volleyball Tournament is chosen as the empirical basis for this study for both methodological and theoretical reasons. The Olympic Games offer a highly standardized environment: men and women play under identical rules, court dimensions, and officiating, with net height being the only technical difference. This ensures that behavioral differences are not confounded by institutional asymmetries. Second, the Olympic level represents the highest international standard, where only elite teams compete. This minimizes disparities in skill and training, enabling us to focus on tactical decisions and risk-taking rather than structural inequalities in ability. Finally, the tournament design combines group-stage matches with knockout rounds, providing natural variation in competitive pressure. Group-stage games allow for recovery after losses, while playoffs

impose elimination consequences. This structure makes it possible to evaluate how athletes adjust their risk-taking under different stakes.

Importantly, in elite volleyball, there is no clear evidence that one serve type systematically produces a higher rally-winning rate in our sample. Players cannot rely solely on risky or solely on safe tactics; instead, they must adapt their choices dynamically. This is well illustrated by serve performance: as shown in Table 2, the percentage of rallies won following different serve types is roughly similar, indicating that both power and float serves can be effective depending on the context.

Table 2: Rally win percentage by serve type (%)

| | **Power serve** | **Float serve** | **p-value (t-test)** |
|---|---|---|---|
| Men | 32.74 | 29.47 | 0.10 |
| Women | 38.85 | 39.92 | 0.66 |

*Notes: The table shows the percentage of rallies won after a given serve type. Differences between serve types are statistically insignificant for women ($t = -0.44$, $p = 0.66$) and marginally significant for men on the 10% level ($t = 1.63$, $p = 0.10$), supporting the idea that no single serve strategy dominates.*

The men's and women's tournaments followed identical formats. Each included 12 national teams, organized into three groups of four. During the group stage, teams played a single round-robin (18 matches per tournament). The top two teams from each group, plus the two best third-placed teams, advanced to the knockout stage, which consisted of quarterfinals, semifinals, a bronze-medal match, and the final (8 matches).

In total, we analyzed 26 matches per gender, yielding over 8,000 rallies. The unit of analysis is the rally: each point represents a discrete decision-making moment, beginning with a serve and ending with the awarding of a point. This micro-level structure enables us to study risk-taking in real time, across different contexts of the match and tournament.

Table 3: Tournament structure and dataset overview

| **Gender** | **Group matches** | **Playoffs** | **Total matches** | **Total rallies (coded)** |
|---|---|---|---|---|
| Men | 18 | 8 | 26 | **4,522** |
| Women | 18 | 8 | 26 | **4,148** |

*Notes: Both tournaments followed identical structure. Each included 12 national teams, with group and playoff stages. The dataset covers all 26 matches in each tournament.*

All matches were manually coded by the authors from official Olympic broadcasts. For each rally, detailed spreadsheets were created to record contextual variables and tactical actions.

The dataset includes:

- Team gender (male/female),
- Tournament stage (group, quarterfinal, semifinal, bronze-medal match, final),
- Team identifier (country),
- Match score at the time of the rally,
- Serve type (power, short, float/standing),
- Attack zone (zones 2, 3, 4),
- Attack direction (line, cross-court, tip/roll shot),
- Use of risky tactical improvisations (e.g., setter dump, tactical substitution of servers).

After data entry, integrity checks were performed. Ambiguous rallies (e.g., disputed referee decisions without video confirmation) were excluded. Rallies with technical problems (such as interrupted broadcasts) were also dropped.

The final dataset comprises 8,670 rallies from the 2024 Olympic volleyball tournaments. After excluding 16 rallies, the data represent over 99% of all completed men's and women's rallies.

# 5 Methodology

The empirical strategy relies on separate model estimations for the men's and women's tournaments, which ensures comparability across groups and allows us to examine gender-specific patterns in risk-taking behavior and how these patterns vary with competitive context. In total, eight linear regressions were estimated, four for each gender, corresponding to the following dependent variables (Table 4): the share of power serves, the share of float serves, the share of a down-the-line attack and the share of a middle (zone 3) attack. For robustness check purposes, for binary serve variables we also estimate the corresponding logistic regressions. Each model incorporates an identical set of contextual predictors capturing situational pressure and match dynamics, as defined in Table 4. This specification links tactical choices directly to the competitive context and provides the empirical basis for testing hypotheses H1–H4. The models for each dependent variable are specified as follows:

$$\begin{aligned}\text{Power Serve}_i =& \beta_0 + \beta_1 \cdot \text{Ranking}_i + \beta_2 \cdot \text{Set Advantage}_i + \beta_3 \cdot \text{Score Difference}_i \\ &+ \beta_4 \cdot \text{Start of Set}_i + \beta_5 \cdot \text{End of Set}_i + \beta_6 \cdot \text{Deuce}_i + \beta_7 \cdot \text{Playoffs}_i + \varepsilon_i\end{aligned}$$

Table 4: Definition of Variables

| **Variable** | **Type** | **Coding / Definition** |
|---|---|---|
| **Dependent variables (risk measures)** | | |
| Power serve | Binary | 1 if a jump power serve is attempted; 0 otherwise |
| Float serve | Binary | 1 if a jump/standing float serve is attempted; 0 otherwise |
| Down-the-line attack | Continuous | Share of down-the-line attacks out of attacks from zones 2/4, excluding rallies with no such attacks |
| Middle (zone 3) attack | Continuous | Share of zone-3 attacks out of all completed attacks, excluding rallies with no attacks |
| **Independent variables (context)** | | |
| FIVB world ranking | Ordinal | 1 = best (lower = stronger); pre-tournament official ranking |
| Set advantage | Integer | Won – lost sets at rally time (e.g., +1 if leading 2–1; -1 if trailing 1–2) |
| Score difference | Continuous | Point margin in the current set (team points – opponent points) |
| Start of set | Binary | 1 if none of the teams reached the score of 10 in sets 1-4, or the score of 5 in set 5; 0 otherwise |
| End of set | Binary | 1 if at least one of the teams reached the score of 20 in sets 1-4, or the score of 10 in set 5; 0 otherwise |
| Deuce | Binary | 1 if score $\geqslant$ 24–24 in sets 1–4, or $\geqslant$ 14–14 in set 5; 0 otherwise |
| Playoffs | Binary | 1 = knockout stage, 0 = group stage |

$$\begin{aligned}\text{Float Serve}_i =& \beta_0 + \beta_1 \cdot \text{Ranking}_i + \beta_2 \cdot \text{Set Advantage}_i + \beta_3 \cdot \text{Score Difference}_i \\ &+ \beta_4 \cdot \text{Start of Set}_i + \beta_5 \cdot \text{End of Set}_i + \beta_6 \cdot \text{Deuce}_i + \beta_7 \cdot \text{Playoffs}_i + \varepsilon_i\end{aligned}$$

$$\begin{aligned}\text{Down-the-Line Attack}_i =& \beta_0 + \beta_1 \cdot \text{Ranking}_i + \beta_2 \cdot \text{Set Advantage}_i + \beta_3 \cdot \text{Score Difference}_i \\ &+ \beta_4 \cdot \text{Start of Set}_i + \beta_5 \cdot \text{End of Set}_i + \beta_6 \cdot \text{Deuce}_i + \beta_7 \cdot \text{Playoffs}_i + \varepsilon_i\end{aligned}$$

$$\begin{aligned}\text{Middle Attack}_i =& \beta_0 + \beta_1 \cdot \text{Ranking}_i + \beta_2 \cdot \text{Set Advantage}_i + \beta_3 \cdot \text{Score Difference}_i \\ &+ \beta_4 \cdot \text{Start of Set}_i + \beta_5 \cdot \text{End of Set}_i + \beta_6 \cdot \text{Deuce}_i + \beta_7 \cdot \text{Playoffs}_i + \varepsilon_i\end{aligned}$$

All regressions were estimated in Python using the pandas, numpy, and statsmodels libraries. Linear models were estimated via ordinary least squares (statsmodels.api.OLS), and binary serve-choice models via logistic regression (statsmodels.api.Logit).

# 6 Results

This section presents the empirical results of our regression analyses, examining how men and women adjust their risk-taking behavior under different game contexts during the 2024 Olympic Games. We report findings separately for each of the four proxies of risk – power serves, float serves, line attacks, and middle attacks – highlighting both similarities across genders and systematic differences.

## 6.1 Power Serves

Power serves are considered the riskiest type of serve and therefore provide a direct measure of risk-taking behavior. The regression analysis reveals distinct gender patterns (Table 5). For men, the probability of attempting a power serve is significantly lower at the start of sets ($\beta = -0.0302$, $p = 0.0197$) but rises sharply toward the end of sets ($\beta = 0.049$, $p = 0.0027$). This suggests that male players begin sets with greater caution but escalate their serving risk in decisive phases, when each rally carries maximum value. The coefficient for the playoff match is positive and statistically significant at the 5% level. Other contextual predictors, such as set advantage, score difference, and deuce, are not statistically significant for men. For women, no systematic changes are observed across different phases of the set. Neither the start nor the end of set variables have a significant impact on serving strategy, indicating a stable approach. The only robust predictor is Ranking ($\beta = 0.0059$, $p < 0.001$), suggesting that lower-ranked (weaker) teams are slightly more likely to attempt power serves. Set advantage does not significantly influence female serving behavior ($\beta = -0.0050$), contrary to earlier expectations. To test the robustness of these results, we also estimate a logistic regression in which the dependent variable is the probability that the serve is a power serve, and the set of independent variables remains the same. The results of

the logistic regression, presented in Table 6, are very similar to those from the linear regression. Taken together, these findings support H1, as men display greater risk propensity than women, particularly in late-set situations under pressure. At the same time, the results contradict H2 in the serving context: instead of adopting conservative strategies at the end of sets, men increase their serving risk, while women maintain an unchanged strategy throughout.

Table 5: Linear regression results for Power serve.

| | **Men** | | **Women** | |
|---|---|---|---|---|
| **Variable** | **Coeff.** | **p-value** | **Coeff.** | **p-value** |
| Set advantage | 0.0051 | 0.3408 | -0.0050 | 0.3061 |
| Score difference | -0.0020 | 0.2868 | 0.0022 | 0.1333 |
| Start of set | -0.0302** | 0.0197 | 0.0102 | 0.3480 |
| End of set | 0.0496*** | 0.0027 | 0.0053 | 0.7041 |
| Deuce | 0.0083 | 0.8955 | -0.0283 | 0.5455 |
| Playoffs | 0.0276** | 0.0327 | 0.0148 | 0.2012 |
| Ranking | -0.0000 | 0.9769 | 0.0059*** | $< 0.001$ |

*Observations: men 4,522; women 4,148; R-squared: men 0.0067; women 0.0077*
*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*
*Positive coefficients indicate a greater likelihood of attempting a power serve.*

Table 6: Logistic regression results for Power serve.

| | **Men** | | **Women** | |
|---|---|---|---|---|
| **Variable** | **Coeff.** | **p-value** | **Coeff.** | **p-value** |
| Set advantage | 0.0331 | 0.3442 | -0.0508 | 0.3052 |
| Score difference | -0.0137 | 0.2737 | 0.0221 | 0.1361 |
| Start of set | -0.1873** | 0.0225 | 0.0989 | 0.3635 |
| End of set | 0.3656*** | 0.002 | 0.0564 | 0.6861 |
| Deuce | 0.0911 | 0.8522 | -0.3452 | 0.5209 |
| Playoffs | 0.1836** | 0.0325 | 0.1433 | 0.2242 |
| Ranking | -0.0002 | 0.9870 | 0.0529*** | $< 0.001$ |

*Observations: men 4,522; women 4,148; Pseudo R-squared: men 0.0071; women 0.0101*
*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*
*Positive coefficients indicate higher likelihood of using a power serve.*

## 6.2 Float Serves

Float serves, considered the safer alternative to power serves, show patterns that largely mirror those observed for riskier serving behavior (Table 7). Among men, the likelihood of using a float serve declines significantly at the end of sets ($\beta = -0.0354$, $p = 0.0151$), indicating a shift toward riskier play when point values are highest.

A similar pattern is not observed when men hold a set advantage ($\beta = -0.0073$, $p = 0.1234$): having a lead has no effect on their serve selection, and they do not switch to more aggressive options.

For women, a tendency emerges. When leading in sets, female players are significantly more likely to attempt float serves ($\beta = 0.0140$, $p = 0.0196$), reflecting a preference for consolidating advantages through conservative strategies. Additional significant results include the influence of playoffs ($\beta = -0.0395$, $p = 0.0053$), where women decrease the use of float serves, and Ranking ($\beta = -0.0115$, $p < 0.001$), which shows that lower-ranked (weaker) women's teams rely less on safe serves. However, no significant adjustments are observed at the end of sets, underlining the stability of women's tactical approach in late phases.

Overall, the results support hypothesis H1, as men demonstrate riskier behavior, such as reducing their use of float serve at the end of a set. Hypothesis H2 is contradicted by the findings: similar to the previous models, women maintain an unchanged strategy at the end of a set, while men, on the contrary, increase their risk. Hypothesis H3 is not supported by the findings: holding a set advantage has no statistically significant effect on men's risk-taking, whereas women adjust their strategy in the opposite direction, favoring safer, more conservative serves. Finally, hypothesis H4 is rejected: in the playoffs, women tend to take more risks, contrary to the expectation of a decrease in risk.

All these results are robust to switching to the corresponding logistic model (see Table 8).

Table 7: Linear regression results for Float serve.

| | Men | | Women | |
|---|---|---|---|---|
| **Variable** | **Coeff.** | **p-value** | **Coeff.** | **p-value** |
| Set advantage | -0.0073 | 0.1234 | 0.0140** | 0.0196 |
| Score difference | -0.0011 | 0.5137 | -0.0022 | 0.2262 |
| Start of set | 0.0175 | 0.1262 | -0.0013 | 0.9219 |
| End of set | -0.0354** | 0.0151 | -0.0090 | 0.5974 |
| Deuce | 0.0245 | 0.6592 | 0.0633 | 0.2707 |
| Playoffs | -0.0217* | 0.0567 | -0.0395*** | 0.0053 |
| Ranking | 0.0023 | 0.1063 | -0.0115*** | $< 0.001$ |

*Observations: men 4,522; women 4,148; R-squared: men 0.0057; women 0.0215*
*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*
*Negative coefficients indicate lower likelihood of using a float serve (less risk-averse, more risk-taking).*

Table 8: Logistic regression results for Float serve.

| | Men | | Women | |
|---|---|---|---|---|
| **Variable** | **Coeff.** | **p-value** | **Coeff.** | **p-value** |
| Set advantage | -0.0603 | 0.1292 | 0.0949** | 0.0188 |
| Score difference | -0.0098 | 0.4912 | -0.0145 | 0.2245 |
| Start of set | 0.1389 | 0.1354 | -0.0057 | 0.9495 |
| End of set | -0.3362** | 0.0122 | -0.0624 | 0.5792 |
| Deuce | 0.2397 | 0.6267 | 0.5130 | 0.2553 |
| Playoffs | -0.1882* | 0.0559 | -0.2593*** | 0.0065 |
| Ranking | 0.0174 | 0.1250 | -0.0676*** | $< 0.001$ |

*Observations: men 4,522; women 4,148; Pseudo R-squared: men 0.0072; women 0.0200*
*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*
*Negative coefficients indicate lower likelihood of using a float serve (more risk-taking).*

## 6.3 Line Attacks

The analysis of line attacks reveals a broadly consistent trend across genders. Both men and women reduce the share of down-the-line attacks toward the end of sets. For men, the coefficient on the end-of-set variable is negative and significant ($\beta = -0.0651$, $p = 0.0068$), showing that players avoid high-risk line shots when each rally carries maximum importance. For women, the effect is similar in size and direction ($\beta = -0.0624$, $p = 0.0026$), again pointing to a decrease of risk in late-set phases. This pattern supports H2, as athletes of both genders adopt more conservative

attacking strategies when the value of each point rises.

Differences emerge, however, once tournament stage is taken into account. Women are significantly more likely to employ line attacks in playoffs ($\beta = 0.0793$, $p < 0.001$), while no corresponding effect is found for men.

Table 9: Regression results for the Share of line attacks.

| | **Men** | | **Women** | |
|---|---|---|---|---|
| **Variable** | **Coeff.** | **p-value** | **Coeff.** | **p-value** |
| Set advantage | 0.0026 | 0.7359 | 0.0004 | 0.9520 |
| Score difference | -0.0034 | 0.2062 | 0.0019 | 0.3864 |
| Start of set | 0.0108 | 0.5589 | 0.0055 | 0.740 |
| End of set | -0.0651*** | 0.0068 | -0.0624*** | 0.0026 |
| Deuce | -0.1128 | 0.1957 | -0.0556 | 0.3943 |
| Playoffs | 0.0211 | 0.2571 | 0.0793*** | $< 0.001$ |
| Ranking | -0.0011 | 0.6292 | -0.0028 | 0.1207 |

*Observations: men 2,779; women 3,236; R-squared: men 0.0060; women 0.0162*
*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*
*Higher values indicate larger share of down-the-line attacks.*

## 6.4 Middle Attacks

Middle attacks, performed from zone 3 and requiring rapid execution and coordination, represent one of the most risk-sensitive elements of offensive play. The regression results show clear phase-specific patterns. For men, the share of middle attacks decreases late in sets ($\beta = -0.0404$, $p = 0.0442$), indicating a shift away from riskier options as point values increase. Similarly, women show a decrease in middle attack frequency late in the game ($\beta = -0.0382$, $p = 0.0266$).

Therefore, H2 is supported for both genders: they shift toward more conservative strategies in the closing phase of sets. Conversely, hypothesis H4 is not supported for men, as they increase the use of middle attacks during playoff matches ($\beta = 0.0310$, $p = 0.0413$), demonstrating heightened risk-taking in high-stakes elimination contexts.

## 6.5 Summary

The analysis of rally-level data from the 2024 Olympic volleyball tournaments provides clear evidence on how gender and context shape risk-taking behavior. The results allow us to evaluate

Table 10: Regression results for the Share of middle attacks.

| | Men | | Women | |
|---|---|---|---|---|
| **Variable** | **Coeff.** | **p-value** | **Coeff.** | **p-value** |
| Set advantage | 0.0097 | 0.1292 | -0.0005 | 0.9270 |
| Score difference | -0.0015 | 0.4958 | 0.0027 | 0.1282 |
| Start of set | 0.0242 | 0.1079 | 0.0101 | 0.4567 |
| End of set | -0.0404** | 0.0442 | -0.0382** | 0.0266 |
| Deuce | -0.0087 | 0.9060 | -0.0896 | 0.1140 |
| Playoffs | 0.0310** | 0.0413 | -0.0063 | 0.6587 |
| Ranking | 0.0019 | 0.2911 | 0.0013 | 0.3698 |

*Observations: men 3,493; women 3,881; R-squared: men 0.0047; women 0.0041*
*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*
*Higher values indicate a larger share of middle (zone 3) attacks.*

the four hypotheses and highlight both systematic gender differences and consistent situational effects.

Table 11: Hypotheses testing results across models.

| **Hypothesis** | **Model 1 Power serve** | **Model 2 Float serve** | **Model 3 Line attack ratio** | **Model 4 Middle attack ratio** |
|---|---|---|---|---|
| H1 | + | + | | |
| H2 | - (men) | - (men) | + | + |
| H3 | | - (women) | | |
| H4 | - (men) | - | - (women) | - (men) |

*Notes: A plus sign (+) indicates that the hypothesis was not rejected in the corresponding model, a minus sign (–) indicates it was rejected, and a blank cell suggests no statistically significant relationship was found. Gender-specific results are noted in parentheses where applicable.*

H1 (Gender). The findings are consistent with the hypothesis that men are more risk-prone than women. Male players on average increase the use of risky serves at the end of sets.

H2 (Set dynamics). The results for the second hypothesis are mixed. Toward the end of a set, both men and women adjust their risk-taking, but the direction of this shift depends on the type of action. In attacks, the hypothesis holds: as stakes rise, both genders turn to more conservative choices. In serves, however, the pattern reverses — women maintain their risk level, while men raise theirs, which runs counter to our initial expectation.

H3 (Set leadership). Having a set lead affects risk-taking differently across genders. Women protect a set advantage by playing more conservatively (increasing float serves), whereas men show no response to holding a lead, keeping their serve choices unchanged.

H4 (Tournament stage). Contrary to the ex ante expectation of greater caution in elimination matches, playoff contexts are associated with increased risk-taking. Women are less likely to serve floaters and more likely to use down-the-line attacks in playoffs, while men show an increase in middle (zone-3) attacks and power serves. We therefore reject H4: knockout pressure tends to intensify, not suppress, risk-taking.

Taken together, these results demonstrate that risk attitudes in volleyball not only differ systematically between men and women, but also shift dynamically with score context, set progression, and tournament stage. Men are consistently more risk-taking in serving, while women show stronger risk aversion in late rallies. When competitive stakes are highest in playoff matches, both genders converge toward more aggressive strategies, despite the higher potential cost of errors.

# 7 Discussion

The results of our analysis shed light on how athletes adapt their tactical risk-taking under varying competitive conditions, and how these adaptations differ systematically between men and women. By situating these findings within behavioral theory and gender research, we can better understand the mechanisms that drive decision-making in high-performance contests.

## 7.1 Gendered Patterns in Risk-Taking

These patterns are consistent with decades of research documenting gender differences in risk behavior. Meta-analyses (Byrnes, Miller and Schafer, 1999, Croson and Gneezy, 2009) show that men typically approach risk as a challenge, while women are more likely to perceive it as a threat. Our results align with this view: women's greater caution when holding a set lead, reflected in their greater use of float serves, is consistent with risk aversion when potential losses are salient. Yet the evidence from playoffs complicates this picture. Female athletes increased their share of line attacks during knockout matches, contrary to the hypothesis that high stakes would reduce risk. This finding suggests that elite female athletes may recalibrate their responses under maximum pressure, perhaps treating elimination contexts as opportunities for bold action rather than as threats to be avoided.

## 7.2 The Impact of High Stakes on Risk Preferences

Behavioral economics widely recognizes that the scale of incentives and the cost of errors fundamentally transform agents' attitudes toward risk. Data from the 2024 Olympic Games are consistent with this pattern: tournament pressure escalation is associated with significant shifts in players' strategies. However, contrary to the initial expectations, which dictate the minimization of unforced errors in critical moments, our findings regarding Hypothesis 4 (Tournament Stage) suggest the opposite pattern. When transitioning from the group stage to single-elimination playoff matches, both men and women move toward more aggressive play, but through different tactical channels: men increase the use of power serves and middle attacks, while women reduce float serves and increase down-the-line attacks.

This shift during the playoff stage may be explained by a change in the strategic balance of power in knockout matches. In a situation where a loss implies immediate elimination from the tournament, conservative play against equally matched opponents becomes counterproductive, as predictable actions ease the burden on the opponent's defense and result in a passive defeat. In an attempt to avoid this scenario, players alter their perception of the situation: cautious play is no longer viewed as safe, but rather as a guaranteed surrender of the initiative. To prevent this, teams deliberately choose a strategy aimed at maximizing pressure, where the risk of an error is justified by the opportunity to achieve an immediate breakthrough.

Consequently, higher macro-stakes in the tournament round are associated with bolder play. At the same time, these high stakes enter into a complex interaction with the micro-stakes within the game itself (during set endgames), a detailed analysis of which is presented in the next subsection under Hypothesis 2.

## 7.3 The Role of Loss Aversion

Our empirical results for Hypothesis 2 reveal a significant dichotomy in set endgames: as pressure mounts, athletes increase risk when serving but reduce it when attacking. This finding can be explained through the concept of loss aversion (Kahneman and Tversky, 1979), which states that attitudes toward risk change depending on whether a situation is perceived as protecting an existing benefit or preventing a loss.

A team's own attack after a successful reception represents a "lottery with a positive expected value," since the vast majority of points in volleyball are scored from the attack. In this situation,

the team already possesses a valuable asset with a high probability of success. To protect this asset and avoid losing a nearly guaranteed win due to an unforced error, hitters demonstrate risk aversion. They avoid dangerous down-the-line hits and opt for more reliable cross-court attacks to keep the ball in play and force the opponent to defend. As the end of the set approaches and the stakes rise, this behavioral distortion becomes even more pronounced.

Conversely, the serving situation is a "lottery with a negative expected value." A serve itself rarely scores a point directly (given the low percentage of aces) but gives the opponent a comfortable opportunity to execute their own attack. A cautious, simple serve at the end of a set leads to a passive loss. To avoid this scenario, players shift into a psychological "loss domain" and deliberately take maximum risks: they choose an aggressive power jump serve, willing to accept a high probability of error for a chance to disrupt the opponent's attacking potential. Thus, in the attack, risk is minimized to safeguard a guaranteed opportunity, while on the serve, risk is accepted to combat an imminent threat.

## 7.4 Practical Implications

Beyond academic contributions, the findings also have practical implications. Coaches can anticipate predictable shifts in behavior, such as men's tendency to increase serving risk late in sets or women's caution when leading, and adapt tactical decisions accordingly. Sports psychologists can tailor mental preparation programs to account for gendered responses to stress, helping athletes manage emotions in high-stakes scenarios. Performance analysts and commentators can also use these insights to interpret in-game decisions with greater accuracy, grounding their assessments in behavioral evidence rather than assumptions. In elite volleyball, as in many professional sports, risk is not merely a gamble; it is a deliberate choice shaped by context, experience, and identity. Understanding how and when those choices are made brings us closer to decoding high-performance behavior under pressure.

## 7.5 Limitations

One should not ignore several limitations of this study. First, in any analysis of player behavior, there is an inherent possibility that actions are dictated or heavily influenced by the opponent's strategy and tactics. However, the server has more time to think and is under less immediate pressure from the opposing team's formation and actions compared to in-play situations. Consequently,

statistics related to serves, such as the choice between power and float serves, are likely more precise and less contaminated by external in-game circumstances. This makes serving behavior a particularly clean indicator of a player's deliberate risk preference.

Second, our analysis is restricted to a single tournament, the 2024 Olympic Games. Although the Olympic setting is standardized and elite, the results may not generalize to domestic leagues or junior competitions.

Third, our rally-level data capture observable tactical decisions but not the underlying psychological states, coaching influence, or team instructions that may also drive risk-taking behavior.

### 7.6 Directions for Further Research

Future work should address the limitations of the study by broadening both scope and depth. Additional analysis within this study could examine the effects of player roles (e.g., setters, opposites, middle blockers). Incorporating team-level dynamics could clarify how collective strategies shape individual decisions. Beyond volleyball, extending the framework to other tournaments or team sports would test the generalizability of our findings. Integrating biometric, physiological, or real-time emotional indicators would also enrich our understanding of the mechanisms underlying risk choices. Finally, studying coaching feedback may show how external guidance interacts with athletes' internal states to influence tactical behavior under stress.

## 8 Conclusion

This study set out to investigate how male and female elite volleyball players adjust their risk-taking behavior under competitive pressure, using the unique setting of the 2024 Olympic Games. By analyzing more than 8,000 rallies across 26 matches per gender, we were able to examine tactical decisions in a standardized elite-level environment. The analysis revealed systematic patterns in how strategic decisions vary by gender, context, and pressure. Men consistently took more risks than women, especially when choosing to use powerful, high-risk serves.

Behavior was associated with set progression. Near the end of a set, both male and female athletes attack more cautiously, reducing risky plays to avoid errors (men reduce the number of line attacks while women reduce both line and middle attacks). This aligns with a "gain frame" in prospect theory: since attacks win most points, players aim to protect their advantage when victory

is near, showing classic risk aversion. Serving decisions show the opposite trend. Male players choose riskier serves as the set progresses. Because a serve rarely scores directly, starting the rally from an unfavorable position, it represents a "loss frame" in prospect theory. In this context, athletes are more willing to attempt difficult, high-reward serves to gain an edge, displaying the risk-seeking behavior the theory predicts in such situations. This clear contrast between the safer context of attacking and the riskier nature of serving explains the different approaches observed.

The knockout stage led to more risk-taking, not less. This was especially true for women, who played far more aggressively during elimination matches than in the group stage.

These results indicate that risk-taking in volleyball is not uniform but context-dependent, and is associated with structural incentives. Gender differences emerge not as absolute tendencies but as nuanced adjustments conditioned by score, set phase, and tournament stage. In doing so, the study provides a richer understanding of how risk is managed in team sports, extending behavioral theories into a domain where high-stakes decisions must be fast.

The contribution of this research is as follows. Theoretically, it demonstrates how classic behavioral frameworks can explain real-time decisions in elite volleyball, offering evidence that risk attitudes in sport mirror broader cognitive and emotional mechanisms of decision-making. Empirically, it provides the first rally-level analysis of risk-taking behavior in Olympic volleyball, revealing systematic gender differences under pressure. Practically, the findings can inform coaching strategies, performance analysis, and psychological preparation by highlighting predictable behavioral patterns in high-stakes contexts.

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## Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, GPT-5.5 was used for language proofreading purposes. After using this tool, the authors reviewed and edited the content as needed and take full respon-

sibility for the content of the published article.

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